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Tax competition and governmental efficiency: Theory and evidence *

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Abstract

This paper studies the impact of a government's efficiency on the taxation policy of a state. Namely, we claim that the countries are different both in the way they tax capital and the way they spend the collected revenue. We build a model of 2 countries competing for foreign investment, government of one of them is more efficient than the other one, which means that it is able to produce more public good out of the same revenue. We show that the country with the more efficient government will charge higher income tax from firms. The theoretical predictions are then tested on a sample of OECD countries, years 1996-2005. In general, empirical results are in line with the theory.

Keywords: international taxation, public finance, asymmetric equilibrium, tax competition

JEL-classification: F23, H25, H32, H54, H71, H73

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1 Introduction

This paper studies the impact of a government's efficiency on the international taxation policy of a state. Namely, we claim that when it comes to the competition for foreign investments it is important to account not only the way the countries tax capital but also the way they spend the collected revenue. With regard to this, we differentiate governments of the countries by their productivity when transforming tax revenue into public goods - the concept, which we call governmental efficiency. At the same time, we assume that the firms, when choosing the location of investment, consider not only the tax rate set in the country, but also the quality of public infrastructure present there. The result of this asymmetric tax competition setting is that the capital tax rates are different in equilibrium: the more efficient country attracts investments even with the higher tax, while the less efficient one is forced to use lower fiscal pressure as its only instrument of inducing firms to stay.

The idea of asymmetric equilibrium in fiscal competition for a mobile factor seems to be well supported by the empirical evidence. For instance, in European Union there are basically no restrictions for capital movement, and many studies find the evidence of strategic interaction between European governments.¹ However, the variation of capital income tax rates in member-countries remains high: effective average tax rate (EATR), developed by Devereux and Griffith [2003], ranged in 2005 from 11% in Latvia and Ireland to 32% in Germany. Papers like Baldwin and Krugman [2004], Zissimos and Wooders [2008], Stewart and Webb [2006] point to the fact that despite competition pressure some countries in EU, like Germany, France or Netherlands managed to tax capital heavier than the countries like Ireland, Portugal or Greece. The data on EATR suggest that the gap between the tax rates in these countries is about 4-5 percentage points and persists through years, even though the tax rates have been declining in almost all countries.

While the classical tax competition literature² fails to do so, our paper provides an explanation for asymmetric outcome of fiscal competition game, apparently emerging in the above mentioned example. To obtain this result we are making two main assumptions. From the one side, we claim that governments of the countries are exogenously endowed with different degree

¹See, for example, Devereux, Lockwood, and Redoano [forthcoming], Griffith and Klemm [2004], Nicodème [2006]

²Starting from Oates [1972], Wilson [1986], and Zodrow and Mieszkowski [1986]

of efficiency. Namely, it is assumed that in the framework of two countries government of one of them can produce more public good out of the same revenue. From the other side, firms willing to invest in either of the countries are assumed to have different need for public inputs provided by governments.³ As a result, more efficient country is able to attract investments even when it charges higher tax. It happens because even with high tax the country offers more-than-proportional increase in the level of public good production, and succeeds to attract a large portion of investments. Therefore, it can run a balanced budget, and maintain higher level of tax burden.

There are also alternative explanations for asymmetric equilibrium in the tax competition game. One branch of the literature in the field explores how interaction between symmetric jurisdictions may lead to the asymmetric outcome.⁴ Most of the studies here assume a presence of a scale or agglomeration economies, which eventually, following the terminology of Baldwin and Krugman [2004], turns one jurisdiction into a high-tax core, and other into a low-tax periphery.⁵ At the same time, Zissimos and Wooders [2008], Bénassy-Quéré, Goyalraja, and Trannoy [2007] show that even without agglomeration economies symmetric jurisdictions may turn into asymmetric core and periphery if governments compete in both tax rates and public expenditures: the core would set higher tax rate and provide higher level of public inputs than periphery. While the setup of our model is very similar to Zissimos and Wooders [2008], we assume initial asymmetry between jurisdictions, and thus get a clear direction of asymmetry in equilibrium tax rates. Therefore, we assert that there are other factors but pure luck (as in all papers mentioned above) that create high-tax/low-tax distribution.

Another branch in the current literature, to which our paper is related, explains asymmetric outcome by an exogenously given asymmetry between jurisdictions competing. Usually, the asymmetry concerns the size of the jurisdictions, be it either capital endowment or population (labour). Wilson

³Here we are using the terms "public good" and "public input" interchangeably. In the literature, public input is often referred to an output of government, which benefits mostly businesses, while public good benefits households. In our paper, both public good and public input mean basically the same thing, i.e. some output of the government, which is useful both for firms and households. We explain our assumptions in the Section 2.

⁴For the good overview of tax competition literature, and the one with asymmetric outcomes in particular, refer to Wilson [1999] and to Wilson and Wildasin [2004]

⁵See Baldwin and Krugman [2004], Kind, Knarvik, and Schjelderup [2000], Ludema and Wooton [2000], Borck and Pflüger [2006], Bucovetsky [2005]

[1987] shows that under free trade and free capital movement the country endowed initially with more capital will have higher capital income tax rate. Wilson [1991], Bucovetsky [1991], Haufler and Wooton [1999], Bucovetsky and Haufler [2007] consider jurisdictions with different population and show that the bigger one will set capital income tax higher. Yet, there are no papers, to our knowledge, that account for the efficiency of the governments involved in tax competition. Indeed, all of the studies assume that each jurisdiction can produce the same amount of public good out of one unit of the private good.

At the same time, it is clear that not only the amount of public spending is important for attracting investment but also how efficiently it is spent, and the governments in real world are different in their efficiency. For instance, in European Union the Index of Economic Freedom (IEF), issued annually by Heritage Foundation, adjusted for our purposes, which arguably proxies governmental efficiency quite well,⁶ follows the same pattern as the capital income tax rates: it is on average 30-40 points out of 500 higher for low-tax Greece and Portugal than for high-tax France, Germany or Netherlands.⁷ The negative correlation between effective average tax rate and IEF in EU is clearly seen on the Figure 1. However, while there are many papers studying the impact of jurisdictional freedom (degree of fiscal decentralization) on governmental efficiency,⁸ the other direction of causality - the impact of governmental efficiency on the outcome of competition between jurisdictions - is omitted in the literature.

Our paper is an attempt to fill the above-mentioned gap, present in the existing literature. Namely, we propose the model of two countries, engaged in the competition for the foreign investments. There is continuum of the multinational companies willing to invest in either of two possible locations. They are assumed to be technologically 'attached' to the amount of public good produced in a country. Therefore, they make their investment choices comparing not only the tax rates in the competing countries, but also the reduction of their production cost due to the presence of the business infrastructure. At the same time, the government of one country is relatively more efficient than the government of the other, which allows it to produce rela-

⁶We discuss the proxies for governmental efficiency in Section 3

⁷Which should mean that the latter countries are more efficient, since by definition the bigger IEF means lower ranking of a country

⁸See, for example, Barankay and Lockwood [2007], Khaleghain [2003], Fisman and Gatti [2001], Huther and Shah [1998], Mello and Barenstein [2001], Treisman [2002]

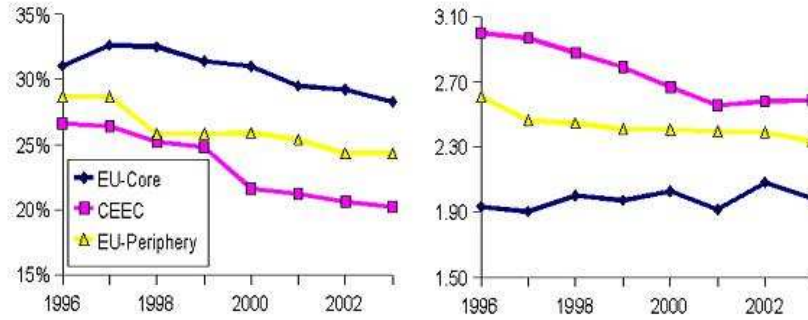


Figure 1: Tax burden vs. governmental efficiency in EU

Unweighted average in 3 groups: EU-Core - France, Germany, Belgium, Netherlands; CEEC - Poland, Czech Republic, Slovakia, Slovenia, Hungary; EU-Periphery - Spain, Portugal, Greece

Y-axis: on the left - effective average tax rate (EATR), on the right - Index of Economic Freedom (IEF) without tax burden, divided by 100

Source: EATR - Devereux and Griffith [2003], Kotans [2005]; IEF - HF [2006]

tively more public goods out of the same tax revenue, and therefore attract more firms. We find that in the equilibrium the more efficient country always sets the tax higher than the less efficient one.

Finally, we test the model empirically, using the data of 28 countries, from 1996 to 2005. As a proxy for tax burden we use the effective average tax rate (EATR), which is calculated from the statutory capital income tax rates adjusted with the country-specific taxation legislation. EATR basically defines the share of the firm's future cash flow, which it will have to give up for a country's government in case the investment takes place. Governmental efficiency is proxied by the Index of Economic Freedom, and by gross domestic product per capita. The methodology we use is standard for testing for strategic interaction between several players. We find that, indeed, the 'rest-of-the-world' tax rate and the governmental efficiency affect significantly positively the tax rate in a given country. Therefore, the main conclusions of the model are confirmed.

The structure of the paper is the following. In the Section 2 we set up and solve the model, described above. Next Section, 3, is devoted to the empirical testing of the results obtained in the Section 2. Finally, Section 4

concludes.

2 The Model

Here we present a theoretical grounding for the fact, that the tax rates in the countries should not necessarily converge to a common value. Namely, we build a model, in which two countries are engaged in competition for foreign investments. One of the countries is relatively more efficient than the other one, meaning that the government of that country is able to produce relatively more public good out of the same revenue. The countries play a game, in which they choose both the tax rate and the level of public good produced. The result is that in Nash equilibrium more efficient country always charge higher tax than the 'inefficient' one. Moreover, the reaction functions of both countries are upward sloping.

2.1 Setup of the Model

The basic features of our model we borrow from Zissimos and Wooders [2008]. However, we adjust their model to account for differences in governmental efficiency, and this brings quite a significant departure from their results.

The model consists of 2 countries, A and B , and multinational absentee firms, willing to invest in either of these countries. Governments of both countries levy tax on every firm entering the market, and produce public goods out of the collected revenue. Firms make their investment choices taking into account the tax rates and levels of public good production, offered by the governments, τ_A , τ_B , g_A , g_B correspondingly. After locating the production in one of the countries each firm produces one unit of some good and sells it on the world market.

We concentrate first on the behavior of the firms, then go back to the governments.

2.1.1 Firms

We assume continuum of firms in the economy. All of them are owned by absentees, i.e. governments do not take their profits into account when designing their fiscal policy. Public goods, provided by the government, are assumed to affect positively the production technology of each firm. With

regard to this each firm is characterized by parameter s , which is distributed uniformly on $[0, 1]$. The profit function of the firm s (firm of type s) looks the following way:

$$\Pi_i = p - c - \tau_i + s \ln g_i, \quad i \in \{A, B\} \quad (1)$$

Here p is the price of the good on the world market, and c is some cost of producing this good. Both p and c are exogenously given in the model. Neither of them depends on the fiscal policy of a particular government, i.e. they do not change with τ_i and g_i . This way we ignore any price effects of taxation, and assume it is not distortive. This assumption may seem more realistic when one thinks of big multinational firm choosing location for small investment, which will have close-to-nothing effect on the firm's global pricing policy. In general, p and c are not important for our further analysis, and the only thing we demand is that the difference between them is big enough to assure non-negative profits of the firm.

τ_i is the tax firm has to pay if it invests in the country i , and g_i is the amount of public good produced by government i . $s \ln g_i$ is the firm's s cost reduction of producing one unit of the good due to public input. It exerts decreasing returns to scale with regard to g_i , which we would naturally expect, and it is increasing with type of firm s . This way we differentiate between firms, and claim that some of them benefit from public infrastructure present in a country more than the others. For instance, if one thinks of different industries, then, say, a producer of microprocessors or generic drugs will benefit a lot from highly-educated labor, high level of public R&D spending and qualitative copyright laws. Such firms are of high s type. At the same time, a producer of some crop or cheap clothes will not need much public infrastructure and care more about the taxes it pays. Therefore, it has low s type.

Each firm faces the tax rates in counties A and B - τ_A and τ_B respectively, and the levels of public good provision - g_A and g_B . For every s if $-\tau_A + s \ln g_A > -\tau_B + s \ln g_B$ then firm s invests in the country A , if $-\tau_A + s \ln g_A < -\tau_B + s \ln g_B$ then it goes to the country B . Otherwise, firm s is indifferent. As a result, share of the firms \hat{s}_B will go to country B , the others $\hat{s}_A = 1 - \hat{s}_B$ will go to A . Obviously, both \hat{s}_A and \hat{s}_B are between 0 and 1, and both depend on strategic interaction between governments.

Finding the expression for $\hat{s}_B = \hat{s}_B(\tau_A, \tau_B, g_A, g_B)$ is crucial for further analysis. We proceed with the following lemma:

Lemma 2.1 *Depending on τ_A , τ_B , g_A , and g_B \hat{s}_B can only take values 0, 1, \hat{s} , or $1 - \hat{s}$ where*

$$\hat{s} = \frac{\tau_A - \tau_B}{\ln g_A - \ln g_B}. \quad (2)$$

In particular, when $\tau_A > \tau_B$, $g_A > g_B$, and the difference between tax rates is sufficiently small:

$$0 < \hat{s}_B = \hat{s} < 1 \quad (3)$$

and \hat{s} is the type of firm, which is indifferent between investing in either of countries.

Proof See the Appendix A.1 ■

Lemma 2.1 tells that if there exists a firm of type \hat{s} , the after-tax profits of which will be equal in both countries, firms of higher type will be willing to invest in the country with higher tax rate, but also with higher level of public good provision. On a contrary, firms of lower type will invest in low-tax-low-public-good-provision country.

We continue with the governments in the model.

2.1.2 Governments

Each government sets the tax rate and chooses the level of public good provision in a jurisdiction. It's objective is to maximize the difference between the revenue it collects from investors and the amount it spends to produce public goods.

The objective function of the governments A and B look the following way:

- government A , given τ_B and g_B , -

$$\max_{\tau_A, g_A} \tau_A * (1 - \hat{s}_B) - g_A/b, \quad b > 1 \quad (4)$$

- government B , given τ_A and g_A , -

$$\max_{\tau_B, g_B} \tau_B * \hat{s}_B - g_B, \quad (5)$$

where $\hat{s}_B = \hat{s}_B(\tau_A, \tau_B, g_A, g_B)$ is determined jointly by the decisions of government A and government B .

$\tau_A * (1 - \hat{s}_B)$ in the objective function (4) is the total revenue of government A - tax rate τ_A multiplied by a tax base of the government A , which is equal to the share of firms $\hat{s}_A = 1 - \hat{s}_B$ investing in the country A . Analogously in the objective function (5), $\tau_B * \hat{s}_B$ is the revenue of government B . g_A/b and g_B are the amounts of public spending by governments A and B correspondingly. Governments are assumed to run balanced budget, so g_A/b cannot exceed $\tau_A * (1 - \hat{s}_B)$, and g_B cannot exceed $\tau_B * \hat{s}_B$.

As it can be seen from (4), the transformation from private good into public one is not one-to-one as it is assumed in most of the similar models:⁹ to produce one unit of the public good the government A has to use only $1/b$, $b > 1$ units of the private good, while for the government B the transformation is one-to-one. In this way we assume that the government of the country A is more efficient in producing the public good then the government of the country B , i.e. it is able to produce more units of the public good out of the same amount of the private good. b is referred to as an efficiency parameter.

The objective functions (4)-(5) are consistent with two different views on the nature of a government. First view, firstly developed by Brennan and Buchanan [1980],¹⁰ considers government as an ever-growing Leviathan, interested only in increasing its size and extracting as much rents from holding the office as possible. If we assume malevolent government in our case, and no way households can control it, then maximizing the difference between revenue and spending means exactly maximizing the rents from holding the office.

From the other side, under our initial assumptions, the government can also be considered as the one maximizing country's welfare. Indeed, as all firms are owned by absentee, the government is not taking into account the firms' profits. Additionally, we ignore all the price effects, which may be caused by fiscal policy, and we abstract from all the possible good and bad sides of FDI.¹¹ As a result, the only way the firms affect the welfare of the country is by paying the tax to the government. The revenue less public expenditures then may be distributed among households or used for production of public goods, which benefit households. Therefore, benevolent government will have the objective function like (4) or (5).¹²

⁹See Introduction for the discussion

¹⁰See also Edwards and Keen [1996], Zissimos and Wooders [2008]

¹¹See, for example, Rama [2001], Javorcik [2004], Chor [2006]

¹²There would be some trade off if we assume that the households receive also utility

It is left to note that the tax base of each government ($(1 - \hat{s}_B)$ for the government A , \hat{s}_B for the government B) depends on the choices of both of them. Therefore they set their tax rates and levels of public good production strategically.

2.2 Solution of the model

Competing for foreign investments, governments are engaged in a tax competition game, where the objective functions are given by (4) and (5). The equilibrium of this game is the intersection of corresponding governmental reaction functions. However, finding of those gets complicated by the fact that function \hat{s}_B is not differentiable everywhere (as we can see from the Lemma 2.1). As a result, the objective functions of both governments are not differentiable at certain points, so we cannot use standard methods of calculus to maximize them.

Intuitively, however, it should be clear that in equilibrium both governments are willing to attract strictly positive share of investments to their countries. Country A , being relatively more efficient, has better chances of doing that by offering to firms high level of public good provision. Consequently, it can also charge high income tax, as a trade-off between higher revenue per firm and smaller share of firms willing to invest in high-tax-high-public-good-provision country. At the same time, country B can attract low- s firms by offering low tax rate. Intuitively, we conjecture then that in equilibrium tax rate, as well as level of public good provision in country A are higher than in country B , and $0 < \hat{s} < 1$ - there exist a firm, which is indifferent between investing in either of two countries. We give a formal proof of our conjecture in the following lemma:

Lemma 2.2 *Suppose we have a game given by equations (4) and (5). Denote by τ_i^* , g_i^* , $i \in \{A, B\}$ the corresponding reaction functions of governments A and B . Then the following statements are true:*

- i. if τ_B is sufficiently big (for any $0 < g_B < \tau_B$) then it is optimal for the government A to follow "mimicking" strategy, i.e. set $\tau_A^* = \tau_B$ and $g_A^* = g_B + \epsilon$, where ϵ is infinitesimally small;*

from public inputs produced by the government, as it is argued, for example, by Bénassy-Quéré, Goyalraja, and Trannoy [2007]. For simplicity, we do not touch this issue here

- ii. *there are values of (τ_B, g_B) for which the government A plays $\tau_A^* > \tau_B$ and $g_A^* > g_B$. In particular, this strategy of the government A is optimal in the neighborhood of $(0, 0)$;*
- iii. *for all τ_A it holds that $\tau_B^* < \tau_A$.*

Proof See in Appendix A.2 ■

The Lemma 2.2 tells us two things. First, optimal response of government A depends crucially on the magnitude of τ_B . Indeed, facing the tax rate and level of public good provision from country B government A can always adopt fiscal policy such that to attract all firms. Namely, it can set tax rate equal to τ_B , and produce slightly higher amount of public good. More efficient government A can always do that since both governments run balanced budget. Hence the maximal amount of public good government B can produce is $g_B = \tau_B$,¹³ while government A can use its efficiency advantage and produce up to $g_A = b\tau_B$ with the same tax rate. As a result, government A can always get $\tau_B - g_B/b$ as its rents to holding the office (difference between the revenue and spending, as in it's objective function).

Government A , however, may deviate from the strategy of mimicking government's B fiscal policy. Namely, it can either decrease level of public spending, while leaving tax rate the same (or also decrease it), or it can increase both tax rate and level of public good production. Since types of firms are distributed uniformly on the $[0, 1]$ interval, both strategies will cause decrease in share of firms willing to invest in country A : "decrease" strategy will defer high- s firms from investment, while "increase" strategy will do the same with low- s firms. Despite this decline in \hat{s}_A , the difference between revenue and public spending may still increase: by even higher decrease of public spending in "decrease" strategy, and by even higher increase in tax rate in "increase" strategy.

The Lemma 2.1 tells us that if τ_B is reasonably small the government A will go for "increase" strategy. Therefore, it will find optimal to tax higher the most demanding high- s firms, while letting low- s firms invest in country B . If the tax rate in country B is too high, however, the decline in \hat{s}_A outweighs the increase in tax per firm for those who decide to remain in the economy. This result is quite intuitive, since neither in "decrease" nor in "mimicking" strategy can government A use its efficiency advantage.

¹³That is if government B succeed to attract all firms to the economy

The second statement of the lemma tells that the optimal response of government B will always be lower than the tax in country A . Being disadvantaged by its lower productivity, government B will never adopt "increase" or "mimicking" strategy, and find it optimal to set low tax and low level of public good production, and attract the least demanding low- s firms.

The behavior of both government's reaction functions, given in Lemma 2.2 leads us to the following proposition:

Proposition 2.3 *Suppose the game is given by equations (4) and (5). Then the Nash equilibria exist and in Nash equilibria $\tau_A > \tau_B$, $g_A > g_B$, and*

$$0 < \hat{s}_B = \hat{s} < 1, \text{ where } \hat{s} = \frac{\tau_A - \tau_B}{\ln g_A - \ln g_B} \quad (6)$$

Proof First thing to note is that objective functions of both governments are continuous, therefore both reaction functions will be continuous as well.¹⁴ Now, as it follows from the Lemma 2.2, the optimal τ_A is always not lower than the 45-degree line on (τ_B, τ_A) plane (for sufficiently small τ_B , τ_B smaller than some $\tilde{\tau}_B$, τ_A is strictly above the line, otherwise it is on the line, i.e. $\tau_A = \tau_B$). At the same time, government B , following its optimal taxation strategy, never sets tax higher or equal than τ_A . Therefore, the whole its reaction function lies below the 45-degree line in (τ_A, τ_B) plane, or equivalently, above 45-degree line in (τ_B, τ_A) plane. Both reaction functions are continuous, and on the interval $[0, \tilde{\tau}_B]$ function $\tau_A - (\tau_B)^{-1}$ changes its sign.¹⁵ Hence, optimal response functions intercept in the area above the 45-degree line in (τ_B, τ_A) plane (on the interval $[0, \tilde{\tau}_B]$). $\tau_B^{NE} < \tilde{\tau}_B$ in this interval, so $\tau_A^{NE} > \tau_B^{NE}$.

g_A^{NE} should also be higher than g_B^{NE} since otherwise all firms will invest in country B , and it is not optimal. Hence, following Lemma 2.1, the share of firms investing in country B in equilibrium is strictly between 0 and 1 - statement (6) holds. ■

In Proposition 2.3 we prove the main result of our paper: in equilibrium, more efficient country sets tax rate higher. It gives up some share of low- s type firms, but taxes the remaining firms heavier. At the same time, having no other instruments, less efficient country finds it optimal to attract investment with the help of tax dumping.

¹⁴See Fudenberg and Tirole [1991] for the proof

¹⁵ $(\tau_B)^{-1}$ here is the inverse function of government's B optimal response

Besides the main result, the proposition also establishes the fact that in equilibrium \hat{s}_B is strictly between 0 and 1, and equals to \hat{s} . This allows us to specify further the objective functions of the governments, and to find Nash equilibrium explicitly. We will need this for the empirical part of the paper.

2.2.1 Additional properties of the model

In this section we provide few auxiliary results, which we will use in the empirical part of the paper. In particular, we show that the reaction functions of the governments are increasing with corresponding tax rate and the efficiency parameter b .

Following the Proposition 2.3, we know that the solution of the game (4)-(5) lies in the range where both governmental objective functions are differentiable, so we can rewrite them and use standard calculus methods for further analysis.

The objective functions of the governments will look the following way:

- government A -

$$\max_{\tau_A, g_A} \tau_A * \left(1 - \frac{\tau_A - \tau_B}{\ln g_A - \ln g_B}\right) - g_A/b \quad (7)$$

- government B -

$$\max_{\tau_B, g_B} \tau_B * \frac{\tau_A - \tau_B}{\ln g_A - \ln g_B} - g_B \quad (8)$$

For simplicity, we denote $\Delta = \ln g_A - \ln g_B$ then:

$$\Delta'_{g_A} = \frac{1}{g_A}, \quad \Delta'_{g_B} = -\frac{1}{g_B} \quad (9)$$

The first order conditions of problems (7)-(8) will look the following way:

- from objective function of government A -

$$1 - \frac{\tau_A - \tau_B}{\Delta} - \frac{\tau_A}{\Delta} = 0, \quad (10)$$

$$\tau_A \frac{\tau_A - \tau_B}{\Delta^2} \frac{1}{g_A} - \frac{1}{b} = 0 \quad (11)$$

- from objective function of government B -

$$\frac{\tau_A - \tau_B}{\Delta} - \frac{\tau_B}{\Delta} = 0, \quad (12)$$

$$\tau_B \frac{\tau_A - \tau_B}{\Delta} \frac{1}{g_B} - 1 = 0 \quad (13)$$

Optimal response (τ_A^*, g_A^*) of government A is implicitly given by identities (10)-(11). Identities (12)-(13) define optimal response of government B (τ_B^*, g_B^*) as a function of τ_A and g_A . We continue with the following proposition:

Proposition 2.4 *Suppose the game is given by (10)-(11). Then:*

- i. τ_A^* is increasing function of τ_B - reaction function of the government A is upward sloping;*
- ii. τ_A^* is increasing function of b - optimal response of government A increases with its efficiency;*
- iii. τ_B^* is increasing function of τ_A - reaction function of the government B is upward sloping.*

Proof See in the Appendix A.3 ■

The Proposition 2.4 basically supports general findings in the tax competition literature¹⁶ that more aggressive fiscal policy of one government should cause similar reaction from other governments. If government B decides to raise the tax rate, government A will get an opportunity to do the same thing without affecting or even increasing the share of firms investing in the country. Thus the difference between revenue and public spending will increase, so such policy response will be optimal. Similar logic works with government B as well, and asymmetry of countries does not play any role in this situation.

Another statement of the proposition tells that the fiscal policy of the government A becomes more aggressive with the increase in its efficiency, i.e. the higher is the b the higher is the tax rate in country A , leaving τ_B and g_B the same. This is quite intuitive result, which is consistent with the logic of the paper in general. Indeed, a government becomes more efficient, so it is able to produce even more public good out of the same revenue. Therefore, even after increase in tax rate it can still attract high- s firms by offering even better public infrastructure.

¹⁶See Wilson [1999] for review

2.3 Conclusions

The main result of this section, shown in Proposition 2.3, is that in equilibrium more efficient country charges higher tax on investment. It happens because in optimum government A decides to extract rents from its efficiency and raises tax rate above the government's B level. Thus it gives up some part of the least demanding firms, but collects higher revenue from those who stay. From the other side, government B is forced to set lower tax, since it is the only way it can compete with more efficient country for foreign investments. This way we explain an empirical fact that despite the harsh competition for mobile tax base some governments manage to sustain high level of taxes still attracting firms to economies.

The reaction functions of both governments are proved to be increasing, which together with the main result, is a testable prediction of the model. Indeed, it is optimal for both countries to increase the tax rate in response to the same action of the neighbor's government. Another testable prediction of our model is that the fiscal policy of the government A becomes more aggressive with increase in b , i.e. we claim that getting more efficient a government should charge a higher tax on foreign investments, other things being equal. As a result, in equilibrium the difference between tax rates in two countries gets bigger with the difference between the productivity of their governments.

We proceed further with the estimation of the model.

3 Testing of the Theory

We now turn to the empirical testing the model. In doing so we follow Devereux, Lockwood, and Redoano [forthcoming] and Brueckner [2003] in their methodology. Specifically, we run IV estimation on a cross-section of 28 countries, years from 1996 to 2005. Accounting for a few control variables, we find the coefficients near the 'rest-of-the-world' average tax rate and near the proxy for governmental efficiency to be highly significant and positive, as it was predicted by the theory.

The structure of the chapter is the following. Section 3.1 describes the estimation model and some econometrics issues concerned with its estimation. Definitions of variables, used in the regression, are given in the Section 3.2, the results are presented in the Section 3.3.

3.1 Econometric Model

Extending our theoretical model to n countries we obtain the system of equations:

$$\tau_{i,t} = R_i(\tau_{-i,t}, X_{i,t}), \quad i = 1, \dots, n, \quad t_1 \leq t \leq t_k \quad (14)$$

where $\tau_{i,t}$ denotes the tax rate in the country i in the year t , $\tau_{-i,t}$'s - tax rates in the same year in the rest of the countries in the sample, $X_{i,t}$ is a vector of other variables influencing the tax rate in the country, and $R_i(X)$ denotes the country-specific reaction function. In principle, setting the tax rate government can react differently on the tax rates of each country. However, the estimation of separate coefficients is hardly possible due to a large number of the countries and short time series of the sample. To overcome the above-mentioned difficulty, we take standard approach for testing the presence of the strategic interaction between jurisdictions.¹⁷ Instead of including separate countries in the equation, we calculate the average "world tax rate" supposed to influence the tax rate in the country i . Namely, the following model is estimated:

$$\tau_{i,t} = \alpha + \beta \sum_{j \neq i} \omega_{ij} \tau_{j,t} + \theta_1 X_{i,t,1} + \theta X_{i,t,-1} + \epsilon_{i,t}, \quad i = 1, \dots, n, \quad t_1 \leq t \leq t_k. \quad (15)$$

Similar to above, here t is a time-variable, varying from some initial year t_1 to t_k . n is the number of countries(jurisdictions) in the sample. Then $\tau_{i,t}$ is the tax rate in the country i at the time t . $X_{i,t}$ is the set of control variables for country i at time t . Note that we intently divided vector X on two parts: X_1 and the rest, X_{-1} . This is because we want to stress on the importance of one of the control variables - government efficiency. Finally, ω_{ij} , $i = 1, \dots, n$, $j = 1, \dots, n$ are country-to-country specific weights, used to calculate the average 'rest-of-the-world' tax for a country i . They are assumed to be exogenously given, i.e. defined by the author of the research. Note that the ω_{ij} 's do not change with time. α , β , θ are to be estimated by the regression. We are particularly interested in β and θ_1 . Our model predicts them to be positive.

The choice of ω_{ij} 's in our model is not straightforward. The usual approach in the literature is to take either uniform weights or those based on the distance between the jurisdictions. While we estimate our model with uniform weights, our opinion is that the distance is not the main factor influencing investment decisions and setting tax rates. Therefore, in addition to

¹⁷See Brueckner [2003], Devereux, Lockwood, and Redoano [forthcoming], for example

uniform ω_{ij} 's, we also report results with 4 other kinds of weights. First one is based on the size of the country: the bigger its GDP the bigger is its role in the "rest-of-the-world" tax rate. The other three weights are based on FDI flows between the countries. Namely, we assign bigger weight to more open countries, i.e. those with higher relation of FDI flows to GDP. In the first case we take FDI flows for the last 3 years, in the second - average FDI flows for the period studied. Finally, the last weights matrix is formed using the data on FDI inflows split by geographical area. Having divided the world into several (7 in total) regions, we assume the role of the country j in forming the tax rate in the country i bigger the bigger is the share of investments coming from certain region to the country j (comparing with the investments to the rest of the world), and the bigger is the share of investments from this region to the country i comparing with another regions. We find this weights system most relevant to our estimation framework. At the same time, we report the results with all 5 weights.

Two main econometric issues must be confronted when estimating (5). Firstly, as all τ_i 's at time t are jointly determined, their weighted sum will clearly be endogenous and correlated with the error term. Indeed, it is easy to see if we rewrite the equation (5) in the matrix form:

$$\tau = \beta W \tau + X \theta + \epsilon, \quad (16)$$

where W is the matrix of weights and α is included in vector θ . It is possible now to derive equilibrium τ 's:

$$\tau = (I - \beta W)^{-1} X \theta + (I - \beta W)^{-1} \epsilon, \quad (17)$$

where I is identity matrix. As it can be seen from the equation (17) every element of τ , τ_i , depends on all ϵ 's, which leads to endogeneity in (15), and hence to inconsistent OLS estimates.

The second issue, which stops us from estimating (15) directly, is that the error terms in (15) may be spatially correlated, i.e. ϵ satisfies the relationship:

$$\epsilon = \gamma M \epsilon + \xi, \quad (18)$$

where γ is a certain vector and M is a certain matrix, depending on the relations between error terms. Such correlation may occur when the estimation model does not control for certain jurisdiction-specific characteristics, which may in turn be spatially dependent. As a result, some of ϵ_i 's and ϵ_j 's may be

correlated, which will drive us to the wrong conclusion about the presence of strategic interaction, when there is no such. Refer to Brueckner [2003] for detailed description of these issues.

We follow Devereux, Lockwood, and Redoano [forthcoming] in their methods of resolving these problems. Namely, we use instrumental variables approach. At the first stage we regress $\tau_{i,t}$ on $X_{i,t}$, then use fitted values from the first-stage regression, $\hat{\tau}_{i,t}$, to calculate weighted averages for each country - $\sum_{j \neq i} \omega_{ij} \hat{\tau}_{i,t}$. These fitted values are asymptotically uncorrelated with the error term in (15), therefore OLS will produce consistent estimates. So, on the second stage of our estimation we run the regression (15), but with $\hat{\tau}_{j,t}$ instead of $\tau_{j,t}$ in the right-hand side. In addition, the same very method also helps to resolve our second problem too.

Another way is to use WX as the instrument for $W\tau$ in the same manner as in above paragraph. Substituting the $\sum_{j \neq i} \omega_{ij} \tau_{j,t}$ with the fitted values from the first-stage regression will also lead to production of asymptotically consistent OLS estimates. With slight adjustments in specification, we use both methods in the paper. Even though the directions of the estimates do not change, the second method proved to produce more robust results than the first one.

3.2 Data

We use a sample of 28 countries, years from 1996 till 2005. Countries include EU-15 (except Denmark and Luxembourg), Switzerland, Norway, USA, Canada, Japan, finally Poland, Hungary, Czech Republic, Slovakia, Slovenia, Estonia, Latvia, Lithuania, Bulgaria and Romania. As a result, 280 observations are included in the sample.

As a dependent variable we take widely used nowadays effective average tax rate (EATR¹⁸). It is defined as a proportion of the pre-tax profit from previously invested in the country assets, taken by the state as a tax levy. EATR is calculated for a firm, which invests one unit, financed by equity, debt or retained earnings, into plants or machinery with predefined rate of profitability (usually, 20% per period considered). Then the profits under no-taxation and existing taxation system in the country are compared. EATR, generally, depends heavily on the statutory tax rate, and on the definition of the taxable profit in each separate country, which concerns usually to

¹⁸This is the name of the variable in the regression

depreciation allowances. The indicator is claimed to be the main measure of the tax burden for multinationals choosing the country to invest in. This is definitely what we consider in our model, when firms invest in the country with higher after-tax profit. Therefore we have chosen this measure of the tax rate. At the same time, we also check the results when statutory tax rates are used as a dependent variable. EATR's for 'old'-OECD(i.e. all except CEE countries) countries were calculated by Devereux and Griffith and used in their paper Devereux and Griffith [2002]. For the rest of the countries EATR's were calculated by Bellak, Leibrecht, and Romisch [2005], Jacobs, Spengel, Finkenzeller, and Roche [2004], and Kotans [2005]. Namely, we use the ones adjusted for country-specific inflation and interest rate. Statutory tax rates are also adjusted for local income taxation.

While the choice of the tax burden measure is more or less obvious, it is much more challenging to come up with appropriate proxy of governmental efficiency. Theoretical model solves this issue in a simple way: more efficient government produces more public goods out of the same revenue. However, real life is more complicated and there are several problems with implementation of this measure in our estimation. First is that government produces more than one public good. Moreover, many of them are hardly measurable in quantity (such as defense or law-making) and, especially, quality. Secondly, even if we succeed in measuring these it will be hard to come up with a unified indicator combining all factors and sorting all countries in terms of their efficiency. Therefore, governmental efficiency may be more easily proxied by the less direct indicators, both on the production side (such as level of corruption, which eventually influences level of public good production) and on the side of final outcomes (for instance, macroeconomic indicators of the country - the better they are the more efficient is, apparently, government). At the same time, usage of such proxies makes the results of an estimation less robust.

As a main proxy for governmental efficiency we use Index of Economic Freedom (IEF), issued yearly by the HF [2006]. IEF provides thorough examination of the factors in the country, which contribute to the economic freedom and prosperity. All of them are related to the activity of the government. Namely, the index is the average of 10 indicators: trade policy, fiscal burden of the government, government intervention in the economy, monetary policy, capital flows and foreign investment, banking and finance, wages and prices, property rights, regulation, and informal market activity. All these fields, apparently, are influenced by the governmental efficiency.

At the same time, economic freedom and efficiency are not necessarily positively correlated. Such factors as government ownership in manufacturing and banking or trade liberalization can have an ambiguous effect on the country, and in particular on its attractiveness for investors. Therefore, we slightly adjust the index for our needs. Namely, we exclude the fiscal burden from the average, since it is already accounted in the model, and in fact is a main object for estimation. We experiment as well with the exclusion of other factors from the final index, but these changes do not seem to affect results significantly. As a result, we obtain the series varying from perfectly free country's 1 to 5 for completely suppressed state. We also calculate relative efficiency index (rel.IEF). That is for a certain year we divide every country's index by the average "rest-of-the-world" index, calculated for each year using the same weights as for the tax rate.

In addition to IEF, we also test our model using other proxies for governmental efficiency. In particular, we report the results when GDP per capita (GDP_capita) is used instead. Indeed, the welfare of the population, characterized quite closely by this indicator, should be a direct consequence of governmental actions, including its policy towards attraction of investments. In addition to GDP per capita, we also control for Leviathan state indicators, in particular share of governmental employees compensation in the country's GDP (govt_compens). It can also be viewed as the proxy for governmental efficiency.

In order to satisfy the assumptions of our theoretical model as well as in order to avoid endogeneity in our estimation we control for several other factors. As a measure of the economy's openness we use amount of foreign direct investments relative to GDP of the country (FDI/GDP). This way the model's assumption about perfect capital mobility is satisfied. In addition, we control for the size of economy (GDP) and average investment project's profitability. As a proxy for this indicator we take annual GDP growth (GDP_growth). As it was mentioned above, we also include measure of Leviathan state (govt_compens) in each regression. Finally, we add country dummies¹⁹ to the model's specification in order to capture country-specific effects. However, we report results of the estimation both with and without country dummies. Firstly, because we capture quite enough shocks by other controls. Secondly, 28 new variables in the regression certainly bring

¹⁹Series x_i such that $x_i(j) = 1$ for country i in each year, and $x_i(j) = 0$ for all other countries

Table 1: Data definitions

Name	Definition	Mean	Med.	Std. Dev.	Min-Max	Source
EATR	effective average tax rate ²⁰ (tax burden)	0.22	0.23	0.08	0.00 - 0.55	Devereux and Griffith [2003], Bellak, Leibrecht, and Romisch [2005], Jacobs, Spengel, Finkenzeller, and Roche [2004], Kotans [2005]
stat_tr	statutory tax rate (tax burden)	0.32	0.34	0.09	0.10-0.57	Devereux and Griffith [2003], Kotans [2005]
IEF	index of economic freedom ²¹ (governmental efficiency)	2.25	2.17	0.54	1.28 - 3.78	HF [2006]
rel_IEF	relative index of economic freedom (governmental efficiency)	1.04	0.98	0.25	0.61 - 1.87	calculated from IEF
GDP_capita	GDP per capita (governmental efficiency), PPP units	20.92K	22.54K	8.98K	5.2K - 42.36K	IMF [2006]
GDP	GDP (size), 10 ⁹ *PPP units	886	194	1912	10 - 12278	IMF [2006]
GDP_growth	annual growth of GDP (expected profitability), %	3.40	3.45	2.69	-9.4 - 11.70	EUROSTAT [2006]
FDI/GDP	FDI to GDP ratio (openness), \$/10 ³ *PPP units	606	311	665	11 - 3039	UNCTAD [2006]
govt_compens	compensation of employees, general government, share of GDP (Leviathan state)	0.11	0.11	0.03	0.01 - 0.24	EUROSTAT [2006]

multicollinearity and make results less robust.

Definitions, sources and certain statistical characteristics of the data used in estimation are presented in the Table 1.

3.3 Results

The results are presented in the tables 2 and 3. Taking into account our "hard" choice of proxies we report the received values for 5 weights in 2 different specifications: first is when the proxy for governmental efficiency is Index of Economics Freedom, and second is when we use GDP per capita instead. We include country dummies in both cases, even though the estimation without them brings relatively analogous results (at least, signs of the coefficients studied do not change). The estimation method used in both specifications is 2SLS with instrumenting weighted average tax directly.²² At the same time, usage of IV's for country's individual tax rates and then calculating weighted average brings analogous results in most cases. Finally, the dependant variable used is EATR adjusted for country-specific inflation and interest rates. Again, the directions of the coefficients studied do not change in most cases when statutory tax rate is used instead.²³

The results reported in the tables fit quite well our theoretical predictions. Indeed, the main prediction of our theoretical model was about the influence of governmental efficiency on the tax rate setting. Usage of both proxies (IEF and GDP per capita) produced the results inline with the theory. Namely, the countries with higher predicted governmental efficiency, proxied correspondingly by Index of Economic Freedom adjusted and GDP per capita, tend to tax capital income heavier. The coefficient near IEF is negative in all 5 cases and significantly different from 0. The p -value of it does not exceed 3% level regardlessly of weights, which is very strong evidence in favour of our predictions. The magnitude of the coefficient, -0.05 , means that decrease in Index of Economic Freedom (without accounting a fiscal burden) on 0.1 for some country, which is quite reasonable change for 1-year period,²⁴ should lead to increase of the effective average tax rate on 0.5 percentage points (so that EATR rises from, say, 22% to 22.5%). This is exactly what we predicted since IEF is by definition greater for the govern-

²²Refer to Section 3.1 for more details

²³The exact magnitudes and t -statistics with these specifications are not reported in the paper. However, it is possible to obtain them directly from the author

²⁴Refer to the Table 2 for maximal, minimal and average magnitudes of IEF

ments, which are less efficient, i.e. their average grade for different policies is high.²⁵

At the same time, the coefficient near GDP_capita (see the Table 3) is positive with very high significance. The p -values are somewhat lower than in the case with IEF proxy, but still do not exceed 3% level. This is also inline with our expectations, since higher incomes of the population, as it was argued in the Section 3.1, is usually the outcome of efficient actions of the government. The magnitude of the coefficient is small in levels but quite significant economically, since GDP_capita is measured in power purchasing parity units in the sample, and the mean of it is a 5-digit number (20920 PPP units). As a result, according to our estimations, the increase in annual population income on 1000 PPP (power purchasing parity) units, which is inline with observed in reality GDP and population growths, will lead the EATR to increase by about 0.7 percentage points. Therefore, usage of both proxies support our theoretical predictions.

Additional prediction of our model was that the tax rate in a country should react in the same direction to the changes of taxation levels in other countries. The results, presented in the Tables 2 and 3, support this finding too. Indeed, the coefficient near "rest-of-the-world" tax, which basically estimates the slope of the governmental reaction function, is significantly positive in all 10 cases.²⁶ The p -value ranges here from 10 to less than 3 percents, which is comparable with other empirical estimations of interjurisdictional competition in the literature.²⁷ The magnitude of the coefficient is quite big comparing with the results from other studies. However, it is comparable with the results of similar estimation in tax competition.²⁸ In addition, in the most interesting cases of GDP and FDI_geogr weights the change in the "rest-of-the-world" tax rate is forecasted to produce the change of almost the same magnitude in the country's tax rate (coefficient changes from 0.74 to 2.42 in different specifications). It means that if world's average capital income tax rate (with different weights) increases by 1 percentage point, the response of a government of a considered country would also be increase EATR on 1 percentage point, given there are no changes in other controls.

It is worth noting again that the results presented are quite robust.

²⁵See the discussion about our choice of proxies in the Section 3.1

²⁶5 kinds of weights over 2 proxies for governmental efficiency

²⁷See Brueckner [2003] for a survey

²⁸See, for example, Devereux, Lockwood, and Redoano [forthcoming]

Table 2: The results of the estimation: IEF as proxy
Dependent Variable: EATR
Method: Least Squares
Number of observations: 280
Proxy for governmental efficiency: IEF

Weights	FDI_3y	FDI_av	GDP	FDI_ geogr	uniform
av_tax_ fitted ²⁹	2.85 (2.33 ³⁰)	2.82 (2.28)	0.74 (2.04)	1.01 (1.65)	1.09 (2.18)
IEF	-0.05 (3.21)	-0.05 (3.28)	-0.05 (3.31)	-0.05 (3.13)	-0.05 (3.15)
GDP	5.7E-7 (0.05)	1.3E-7 (0.11)	2.3E-6 (0.19)	5.5E-7 (0.05)	-1.2E-7 (0.01)
GDP_ growth	0.002 (1.29)	0.002 (1.37)	0.002 (1.47)	0.002 (1.45)	0.002 (1.30)
FDI/GDP	1.9E-5 (1.49)	2.0E-5 (1.54)	1.8E-5 (1.40)	1.7E-5 (1.26)	1.8E-5 (1.40)
govt_ compens	-0.64 (3.46)	-0.63 (3.33)	-0.63 (3.34)	-0.65 (3.37)	-0.69 (3.88)
R- squared	0.65	0.65	0.64	0.64	0.64

Table 3: The results of the estimation: GDP per capita as proxy
Dependent Variable: EATR
Method: Least Squares
Number of observations: 280
Proxy for governmental efficiency: GDP_capita

Weights	FDI_3y	FDI_av	GDP	FDI_ geogr	uniform
av_tax_ fitted ³¹	4.86 (3.11 ³²)	5.34 (3.16)	1.14 (2.36)	2.42 (2.45)	1.98 (3.04)
GDP_ capita	6.5E-6 (2.95)	7.4E-6 (3.12)	6.28E-6 (2.55)	8.0E-6 (2.71)	6.6E-6 (2.93)
GDP	-1.4E-5 (1.21)	-1.5E-5 (1.23)	-1.2E-5 (1.04)	-1.3E-5 (1.08)	-1.5E-5 (1.25)
GDP_ growth	0.002 (1.15)	0.002 (1.28)	0.002 (1.43)	0.002 (1.51)	0.002 (1.17)
FDI/GDP	-1.4E-6 (0.10)	-1.3E-6 (0.09)	-2.9E-6 (0.20)	3.5E-6 (0.24)	-2.6E-6 (0.18)
govt_ compens	-0.65 (3.49)	-0.61 (3.26)	-0.65 (3.39)	-0.60 (3.05)	-0.73 (4.06)
R- squared	0.64	0.64	0.64	0.64	0.64

Firstly, they are consistent through all 5 kinds of wages. Secondly, when another specification is used the results do not change significantly. Namely, it concerns choice of dependant variable, choice of proxy for governmental efficiency, method of IV estimation, and inclusion of country dummies. Therefore, we can conclude that strong support of our theory is found.

4 Conclusions

This paper studies the influence of the relative governmental efficiency on the outcome of international tax competition game between two countries. By the relative efficiency here we mean the fact that the more efficient government is the more units of the public good it is able to produce out of one unit of the private good. We build the model with two countries, engaged in the competition for foreign investments. Multinationals are assumed to be technologically 'attached' to the level of the public good provision in the country, i.e. the more of the public good is provided by the country the less it costs to produce there. Therefore, they make their choice of the investment placement based not only on the tax rate they face, but also on the potential reduction of the production costs.

We find, that in equilibrium more efficient country always sets the tax higher than the less efficient one. Moreover, the response functions of the governments are found to be increasing, which is in compliance with the existing literature. Another finding is that the reaction functions become steeper with the increase in governmental efficiency.

Further, the model is empirically tested on 28 countries, years from 1996 to 2005. We find "the-rest-of-the-world" average tax rate and the governmental efficiency to affect significantly positively the tax rate in a certain country, which supports the conclusions of the model. We also find quite a strong evidence in favor of our predictions on slope of the reaction function.

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A Proofs of the propositions

A.1 Lemma 2.1

Firm s compares its after-tax profits in both countries:

$$\Pi_A = p - c - \tau_A + s \ln g_A \text{ vs. } \Pi_B = p - c - \tau_B + s \ln g_B \quad (19)$$

Immediately few cases are clear:

- If $\tau_A \geq \tau_B$ and $g_A \leq g_B$ ³³ then firm of any type will pay less taxes in country B and receive more public inputs. Therefore, $\hat{s}_B = 1$.
- On a contrary, if $\tau_A \leq \tau_B$ and $g_A \geq g_B$ then all firms will invest in country A : $\hat{s}_B = 0$
- The case, we are interested in, is when $\tau_A > \tau_B$ and $g_A > g_B$. Firm s will invest in country B if:

$$\Pi_A = p - c - \tau_A + s \ln g_A < \Pi_B = p - c - \tau_B + s \ln g_B \quad (20)$$

With the given restrictions on tax rates and levels of public good provision we can solve this inequality directly. The solution is:

$$s < \frac{\tau_A - \tau_B}{\ln g_A - \ln g_B} = \hat{s} \quad (21)$$

Therefore,

$$\hat{s}_B = \begin{cases} \hat{s} & \text{if } \tau_A - \tau_B < \ln g_A - \ln g_B, \\ 1 & \text{otherwise,} \end{cases} \quad (22)$$

which was needed to prove.

Note that $\tau_A \neq \tau_B$ in this case, so \hat{s} is never 0. Moreover, \hat{s} is the solution of the equation:

$$\Pi_A = \Pi_B, \quad (23)$$

i.e. if difference in tax rates is sufficiently small (refer to equation (22)) then \hat{s} is the type of firm, which is indifferent between investing in either of two countries.

- The final case, when $\tau_A < \tau_B$ and $g_A < g_B$ will lead us to the inequality, similar to (21), only with the reverse sign. As a result, $\hat{s}_B = 1 - \hat{s}$, if again the difference in tax rates is not too big. Otherwise, $\hat{s}_B = 0$.

³³We assume that tax rates and levels of public good provision cannot be equal simultaneously. If it is so, then \hat{s}_B is undetermined

A.2 Lemma 2.2

Suppose the strategy of the government B is to play (τ_B, g_B) . Government A has then several options:

- i. $\tau_A = \tau_B$, $g_A = g_B$ - "mimicking" strategy. Using its relative efficiency government A can set the tax rate to τ_B and produce slightly more of public good. This way it attracts all the firms to the country, so the revenue of A is:

$$Rev^M = \tau_B - \frac{g_B}{b} \quad (24)$$

- ii. $\tau_A > \tau_B$, $g_A \leq g_B$ - unfeasible strategy, since all firms invest in country B in this case;
- iii. $\tau_A \leq \tau_B$, $g_A > g_B$ - A does not play this strategy either - even though all firms invest in A in this case, revenue is higher with "mimicking" strategy;
- iv. $\tau_A < \tau_B$, $g_A < g_B$ - "decrease" strategy;
- v. $\tau_A > \tau_B$, $g_A > g_B$ - "increase" strategy.

First we note that A is always better playing "increase" strategy than "decrease" strategy. Indeed, it is cheap for A to produce public goods, and it can attract firms by doing that at the same time increasing the tax rate.

Now we have to check if "increase" strategy is better than "mimicking" strategy. Assume A chooses strategy:

$$\tau_A = \tau_B + \epsilon, \quad g_A = g_B + \mu, \quad \epsilon > 0, \quad \mu > 0, \quad (25)$$

Then the revenue of A is:

$$Rev^I = (\tau_B + \epsilon) \left(1 - \frac{\epsilon}{\ln(g_B + \mu) - \ln g_B}\right) - \frac{g_B + \mu}{b} \quad (26)$$

"Increase" strategy is better than "mimicking" strategy if there exist such $\epsilon > 0$ and $\mu > 0$ that $Rev^I > Rev^M$. This is equivalent to the following inequality:

$$\epsilon - \frac{\epsilon}{\ln(g_B + \mu) - \ln g_B} - \frac{\mu}{b} - \frac{\tau_B \epsilon}{\ln(g_B + \mu) - \ln g_B} > 0 \quad (27)$$

Obviously, when $g_B > 0$ for sufficiently high τ_B this inequality does not hold for any values of ϵ and μ (satisfying governmental budget constraint). This way we have proved part (i) of the lemma.

To prove part (ii) of the lemma we will use inequality (27) again. When $g_B \rightarrow 0$, for any τ_B including 0, the tax base of the government A goes to 1 regardlessly of the increase in the tax rate. Therefore, to get bigger revenue A should just raise the tax more than the level of public good provision. Choosing $\epsilon > \frac{\mu}{b}$ A is better off when playing "increase" strategy.

Finally, part (iii) follows from the fact that government B always plays "decrease" strategy. Indeed, B does not have an advantage before A , and "mimicking" A brings it zero revenue (for some values of τ_A and g_A playing this strategy even violates budget constraint).

A.3 Proposition 2.4

The third statement follows immediately from FOC (12):

$$\tau_B^*(\tau_A, g_A) = \frac{\tau_A}{2}, \quad (28)$$

so τ_B^* is obviously increasing in τ_A .

To get the second statement we first note that from equation (10) it follows that -

$$\tau_A^* = \frac{\Delta + \tau_B}{2}. \quad (29)$$

Then the equation (11) can be rewritten:

$$\frac{1}{g_A^* \Delta} \left(\frac{1}{2} + \frac{\tau_B}{\Delta} \right) - \frac{1}{b} = 0. \quad (30)$$

Now, if we increase τ_B the identity (30) holds if either Δ or $g_A^* \Delta$ increases. Δ increases with τ_B if and only if $\frac{\delta g_A^*}{\delta \tau_B} > 0$, and

$$\frac{\delta}{\delta \tau_B} (g_A^* \Delta) = \frac{\delta g_A^*}{\delta \tau_B} (\Delta + 1) > 0 \Leftrightarrow \frac{\delta g_A^*}{\delta \tau_B} > 0, \quad (31)$$

since Δ is positive by the setup of the problem. As a result, we have to have $\frac{\delta g_A^*}{\delta \tau_B} > 0$, since otherwise both Δ and $g_A^* \Delta$ will be decreasing with τ_B , and identity (30) will not hold. Now,

$$\frac{\delta g_A^*}{\delta \tau_B} > 0 \Rightarrow \frac{\delta \Delta}{\delta \tau_B} > 0 \Rightarrow \frac{\delta \tau_A^*}{\delta \tau_B} = \frac{1}{2} \left(\frac{\delta \Delta}{\delta \tau_B} + 1 \right) > 0, \quad (32)$$

so optimal response of government A increases with τ_B .

The proof of the second statement of the proposition follows the same logic as the proof of the first statement. From the identity (30):

$$b \uparrow \Rightarrow \left[\frac{1}{g_A^* \Delta} \left(\frac{1}{2} + \frac{\tau_B}{\Delta} \right) \right] \downarrow \Rightarrow [g_A^* \Delta] \uparrow \text{ or } \Delta \uparrow \quad (33)$$

Analogously to the proof of the previous statement, it can be shown that $\frac{\delta g_A^*}{\delta b} > 0$, and because of that $\frac{\delta \Delta}{\delta b} > 0$. Therefore, τ_A^* is increasing with b .